Bird communities in remnant woodland on the upper North-west Slopes of New South Wales

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ABSTRACT

Bird counts were conducted in woodland remnants of the upper North-west Slopes of New South Wales, an ornithologically little-documented area, in 1995 and 1997. A total of 120 woodland species, including 11 threatened species, was recorded in the area below 900 m elevation, from a point 100 km NNW of Armidale northwards 50 km to the Dumaresq River, thence 50 km north-west across Slopes woodland to the river at Texas (Queensland). Woodland patches >300 ha supported significantly more species than those <100 ha. Threatened and other declining species occurred mainly in large patches, although some also occurred commonly in small riverine or otherwise fertile patches; foraging guilds of small to medium-sized, ground and above-ground insectivores were under-represented in small remnants. The conservation values of woodland remnants on the upper North-west Slopes are similar to those on the tablelands and inland slopes farther south, and require appropriate management to maintain avian diversity.

Key words: Bird communities; Remnant woodland; Habitat complexity; Species richness.

Introduction

This paper complements a survey of birds in remnant woodland on the Northern Tablelands of New South Wales above 900 m elevation (Debus *et al.* 2006), by comparing the bird communities of woodland remnants on the adjoining North-west Slopes below 900 m elevation. This survey also complements that by Oliver *et al.* (1999), of woodland birds on the adjoining North-west Slopes to the south of the present study area.

The sites surveyed in the present study continue the previous transect (Debus *et al.* 2006) from the 900 m contour northwards to the Queensland border at the confluence of the Beardy and Dumaresq Rivers (320 m elevation), then continuing to a point 50 km downstream on the Dumaresq River (260 m elevation). This transect traversed the rugged fall and extensive woodland remnants of the inland slopes, in an area little documented ornithologically but within the historic range of two endangered and seldom-recorded species in NSW (Squatter Pigeon *Geophaps scripta* and Black-throated Finch *Poephila cincta*). The survey traversed the upper northern-western part of the New England Tableland Bioregion and, mostly, the northernmost part of the Nandewar Bioregion (see Thackway and Creswell 1995).

The primary aim of this study was an inventory of the avifauna of woodland patches, and especially any threatened birds, within an easement corridor for a proposed public utility, in order to identify bird species and woodland areas of high conservation significance. A secondary aim was to compare avian species richness in woodland remnants of different sizes and tenures. Habitat data may identify confounding effects of geological substrate and patch condition on avian species richness in different patch sizes and land tenures (Debus *et al.* 2006). As all patches within the easement corridor were on private land, available data for two large national parks adjacent to the corridor are compared with the survey results.

Study area and methods

The study area continued from Kings Plains (29°37'S, 151°25'E) 100 km north-north-west of Armidale (see Debus *et al.* 2006), northwards in a 50 km transect terminating on the Dumaresq River, 15 km south-east of Bonshaw (29°03'S, 151°16'E). A second stage branched off at the Bonshaw end and proceeded 50 km across Slopes woodland north-west to Texas (28°51'S, 151°10'E), also on the Dumaresq River (Fig. 1).

The physiography, climate and broad vegetation types of the study area are described elsewhere (Heatwole and Simpson 1986; Heatwole *et al.* 1995, 2003). The area traversed is a patchwork of three main bedrock types giving rise to soils of varying fertility: basalt (richest), granite (poorest), and metasediments ('trap'), with fertile Quaternary alluvium on the Dumaresq River. Summer-dominant rainfall ranges from about 800 mm per year at Kings Plains to about 600 mm at Texas; the mean July minimum temperature ranges from 0° to 2°C, respectively.

The survey program was concerned with impact assessment for a proposed public utility, and hence targeted sites of likely biodiversity value. Sites within the specified 2–3 km wide corridor were selected from aerial photographs on the basis of intact tree cover in patches >20 ha in size, regardless of tenure. All such accessible patches within the transect were visited.

The bird survey methods used were as described previously (Debus *et al.* 2006) for 'snapshot' surveys above 900 m in 1995. That is, area searches within 1 km^2 cells in autumn and a series of point counts in spring (see below and Table 1). Woodland patches were similarly classified as large (>300 ha) or small (<100 ha); there were no conservation reserves (or medium-sized patches) within the transect. The smallest remnant was about 25 ha.

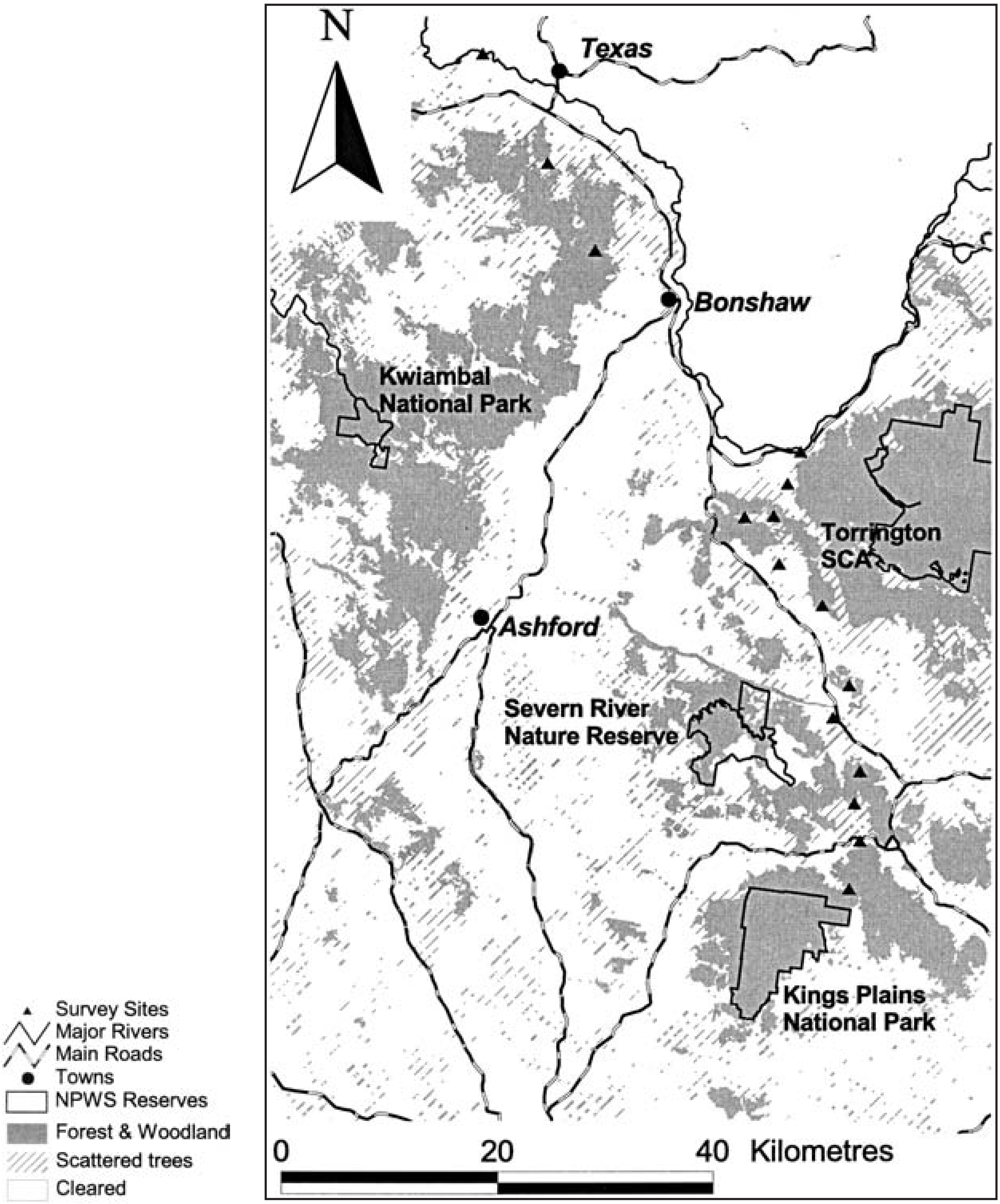
N
Texas
Bonshaw
Kwiambal National Park
Torrington SCA
Ashford
Severn River Nature Reserve
Kings Plains National Park
Survey Sites
Major Rivers
Main Roads
Towns
NPWS Reserves
Forest & Woodland
Scattered trees
Cleared
0
20
40 Kilometres

Figure 1. Map of study area showing survey sites.

Autumn (April) surveys in 1995 were circuitous walking searches within the perimeter of each of two to four representative 1 km^2 cells or part thereof, depending on the size of the woodland patch (13 cells across five patches). Spring (November) surveys in 1995 were three to 19 half-hour point-counts across two to eight points per site, depending on the size of the fragment, conducted by SD, ST, B. Hines, A. Ley, M. Chambers, D. Flockhart, S. Maciejewski and M. Murranyi (47 points across seven patches; 1–3 counts per point). Nocturnal surveys were conducted at all sites and in both seasons, the number of evening surveys proportional to the size of the fragment; the method included call-playback and spotlighting.

Spring (October) surveys on the north-west branch transect in 1997 repeated the procedure used in spring 1995: two to 20 half-hour point-counts across one to eight points per site, depending on the size of the fragment, conducted by SD and ST (18 points across four patches; 2–4 counts per point). Nocturnal surveys were also conducted, at least once at each survey point.

Table 1. Survey period and method for each woodland remnant category (further details in text). Surveys were systematic counts. For large and small remnants on private land, n = no. patches surveyed in total and by season. Three large patches and one small patch surveyed twice (April and November 1995); all other patches surveyed once.

Site	Survey period	Survey method
Large private (>300 ha; n = 10)	Apr. 1995 (n = 3)	Area search
	Nov. 1995 (n = 7)	Point counts
	Oct. 1997 (n = 3)	Point counts
Small private (20–95 ha; n = 5)	Apr. 1995 (n = 2)	Area search
	Nov. 1995 (n = 3)	Point counts
	Oct. 1997 (n = 1)	Point counts

Survey sites and program

1995

Large: seven sites; four surveyed in spring only, and three in autumn and spring. Autumn sites each had two to four 1 km^2 cells surveyed. Spring surveys were from five to 19 half-hour point-counts across four to nine points per site (1–3 counts per point, usually 2).

Small: four sites, one surveyed in autumn only, two in spring only, and one in both seasons. Autumn sites had all intact woodland within one 1 km^2 cell (or part thereof) surveyed. Spring surveys were two half-hour point-counts at each of two points per site.

1997

Large: three sites; 16 to 20 half-hour point-counts across four to eight points per site (2–4 counts per point, usually 4).

Small: one site; two half-hour point-counts at one point.

Survey intensity was variable within large remnants, and violated the ‘equal time’ rule (Mac Nally and Horrocks 2002) for small remnants, of which there were also fewer than for large remnants. Distance from neighbouring patches, and degree of isolation of subject patches, were not stratified or quantified. Data were collated as species presence/absence at each survey site. Only open-forest and woodland birds are considered here.

Habitats

Remnant size generally varied with lithology (i.e. soil nutrient status): large patches were on rocky, granitic or sedimentary (infertile) soils, and small remnants were on basalt or riverine alluvium (fertile soil) except for one patch on a rocky ridge-top. Large patches were heterogeneous floristically and topographically, with survey points in ridge, slope and gully positions, whereas small patches were less variable, usually with a single vegetation type and topographic position (except for the ridge site, which was cut by a creek gully). To the extent possible, large and small patches were distributed fairly equally along the transect: large (n = 10) were distributed throughout; small occurred in the upland (1), middle (1) and lowland riverine parts (3).

The following habitat types occurred at survey sites, approximately in order from south (higher elevation) to north (low elevation). Types 2 and 6 were represented in small patches (with type 2 also occurring marginally in one large patch); the other types were represented in large patches, with type 3 in one small patch (Table 2).

Table 2. Habitat attributes of large and small remnants on private land surveyed during the 1995/97 easement-corridor survey. Totals = number of remnants in which an attribute class was recorded; numbers in parentheses = number of sites sampled in each category. One large site was heterogeneous, with box/gum on basalt represented marginally (shown in parentheses; further habitat details in text).

Attribute		Large (10)	Small (5)
Tree cover (%):	10–30	4	2
	31–50	4	3
	51–70	2	
Shrub cover (%):	<10	1	2
	10–30	7	3
	31–50	2	
Grass height (m):	<0.5	4	4
	>0.5	6	1
Grass cover (%):	<10	1	3
	10–30	4	1
	31–50	4	
	51–70	1	
	>70		1
Hollows (n):	0		1
	1–5	10	3
	6–10		1
Logs (n):	1–5	4	3
	6–10	4	2
	11–20	2	
Geology:	basalt	(1)	1
	alluvium	1	3
	metasediments	4	1
	granite	5	0
Vegetation:	Riverine gum/she-oak		3
	Box/gum	(1)	1
	Eucalypt/cypress pine	10	1

1. Heathy or shrubby open forest or woodland on rocky outcrops: Hill Red Gum *E. dealbata*–Caley’s Ironbark *E. caleyi*–Black Cypress Pine *Callitris endlicheri*; Orange Gum *E. prava*.
2. Grassy woodland on basalt: Eastern Grey Box *E. moluccana*–Blakely’s Red Gum *E. blakelyi*–Rough-barked Apple *Angophora floribunda*.
3. Shrubby or grassy woodland on sediments and granite: Hill Red Gum–Black Cypress Pine; Silver-leaved Ironbark *E. melanophloia*–White Box *E. albens*–White Cypress Pine *Callitris glaucophylla*.

4. Shrubby woodland on Quaternary alluvium: Silver-leaved Ironbark–Smooth-barked Apple *Angophora leiocarpa*–Black Cypress Pine.
5. Grassy woodland on metasediments: Silver-leaved Ironbark–Black Cypress Pine; Silver-leaved Ironbark–Rough-barked Apple–White Cypress Pine.
6. Riparian woodland on Quaternary alluvium: River She-oak *Casuarina cunninghamiana*–River Red Gum *E. camaldulensis*.

The eucalypt/cypress pine types (Table 2), as defined above, occurred in subtle variations along the transect, with type 1 occurring in the upland half of the transect and types 3, 4 and 5 occurring in the middle (3) and lowland (4, 5) parts of the transect.

Habitat attributes (height, cover) at each site were assessed in a 30 m radius around bird-count points, averaged where there was more than one point per patch. Percent cover was the estimated projected foliage cover. The shrub layer tended to be dominated by tea-tree *Leptospermum* and other heath species on rocky areas, biddy bush *Cassinia*, daisy-bush *Olearia*, pine saplings, wattle *Acacia* or tea-tree on other infertile sites, and was sparse to absent on fertile sites; bottlebrush *Callistemon* occurred in river channels.

Conservation status

Throughout this paper, 'threatened', 'vulnerable' and 'endangered' follow the species and criteria listed in the NSW *Threatened Species Conservation Act 1995*.

Results

Large and small patches overlapped in their habitat characteristics, although sites with the greatest tree and shrub cover, and number of logs, were large patches (Table 2). That is, large patches tended to have greater tree, shrub and grass cover, taller grass, and more logs per plot than did small patches. Within-patch variability was also greater in large patches, particularly the patch that had two habitat types and lithologies represented, because large patches encompassed the range of local relief. On average, rather dissimilar (though eucalypt-dominated) habitats were present in large versus small patches, in terms of flora species, topographic position and site productivity.

Overall, habitat remnants in the study area supported a diverse community of 120 woodland or open-forest bird species (Table 3). Large patches (mean 72 species) supported significantly more species than small patches (mean 52 species; Table 4) (two-sample *t*-test: $t_{12} = 3.76$, $P<0.01$). However, this result (total 117 species in large patches, 106 species in small patches) may partly be an artifact of sampling effort. There were only half the number of small remnants surveyed as large remnants, and with fewer survey points per patch; nevertheless, the small remnants collectively captured almost as many species as the large patches. Three species were recorded only in small patches (Whistling Kite, feral Rock Dove, Little Corella), the remainder being a subset of those found in large patches.

The most heterogeneous large patch, in terms of geology and habitat, was near the upper altitudinal limit of the survey and supported a moderate number of species (64). The large patches at the lowland, subtropical end of the transect had the greatest number of species (94–113), in particular one topographically diverse patch with survey points on both sides of a ridge system (113 species).

Eleven threatened species were recorded in the study sites (Table 3), although the Squatter Pigeon and Black-throated Finch were not encountered. Most of the vulnerable large or non-passerine species (cockatoos, owls) and several vulnerable passerines (Black-chinned Honeyeater, Painted Honeyeater, Hooded Robin, Grey-crowned Babbler) were recorded only in large patches. Several other vulnerable species (Square-tailed Kite, Turquoise Parrot, Brown Treecreeper, Speckled Warbler, Diamond Firetail) also occurred, the last three commonly, in small patches.

Many of the other species identified as declining or potentially at-risk (Barrett *et al.* 1994; Reid 1999; Watson *et al.* 2003: see Table 3) occurred in most large patches, but in few small patches (Painted Button-quail, Peaceful Dove, Musk Lorikeet, Jacky Winter, Scarlet and Red-capped Robins, White-browed Babbler, Varied Sittella, Crested Shrike-tit, woodswallows). Nevertheless, several other declining or at-risk species occurred in most small patches (e.g. Weebill, Rufous Whistler, Grey Shrike-thrush, Restless Flycatcher, Double-barred Finch). Small patches were mostly outside the range of the Brown Thornbill, although within the range of its western counterpart, the Inland Thornbill. The Southern Whiteface was recorded in few large patches and no small patches. The Barking Owl *Ninox connivens* was not recorded, but a landholder at one large patch considered, on the basis of playback calls demonstrated, that it occurs there.

Of the declining species occurring on the tablelands (Debus *et al.* 2006), the Yellow Robin occurred in most small patches on the inland slopes (Table 3), and the Scarlet Robin (recorded at three higher and mid-elevation sites on the present transect) was replaced by the Red-capped Robin at lower elevation. The Square-tailed Kite was recorded at three large patches along the 100 km transect, and at one small patch on the lower Dumaresq River.

Of the small patches, a ridge-top site had one of the lowest scores for species richness (42 species), and supported only two of the five threatened species and five of the 14 declining or at-risk species otherwise found in small patches (Table 3). The other four small patches with higher species richness (54–66 species), and supporting the threatened and other significant species, were fertile sites on basalt or on riverine alluvium.

Foraging guilds (after Watson *et al.* 2003) that were under-represented in small remnants, especially the ridge-top site, included (Table 3):

(a) small ground (Southern Whiteface, Jacky Winter) and/or above-ground insectivores ('red' robins, Varied Sittella);

(b) medium-sized ground (Painted Button-quail, Hooded Robin) and/or above-ground insectivores (bronze-cuckoos, Crested Shrike-tit, flycatchers, small cuckoo-shrikes, White-winged Triller, woodswallows);

(c) medium-sized ground granivores (doves);

(d) medium-sized nectarivores (small lorikeets, Painted Honeyeater);

(e) large or specialised carnivores (raptors and owls).

Table 3. Land-bird species recorded in each woodland remnant size category. Totals = number of remnants in which a species was recorded. Numbers in parentheses = number of sites sampled in each category. Bold = threatened species listed in NSW (TSC Act); V = vulnerable, underlined = other species declining or at risk from further habitat fragmentation and degradation in NSW woodlands (from Barrett *et al.* 1994; Reid 1999; Watson et al. 2003). *Introduced.

Species	>300 ha (10)	<100 ha (5)
Emu *Dromaius novaehollandiae*	2	
Stubble Quail *Coturnix pectoralis*	1	1
Brown Quail *Coturnix ypsilophora*	1	
Black-shouldered Kite *Elanus axillaris*	1	1
Pacific Baza *Aviceda subcristata*	2	
Square-tailed Kite *Lophoictinia isura* V	3	1
Whistling Kite *Haliastur sphenurus*		2
Brown Goshawk *Accipiter fasciatus*	3	
Wedge-tailed Eagle *Aquila audax*	4	1
Little Eagle *Hieraaetus morphnoides*	5	2
Brown Falcon *Falco berigora*	4	2
Australian Hobby *Falco longipennis*	1	
Peregrine Falcon *Falco peregrinus*	3	
Nankeen Kestrel *Falco cenchroides*	5	2
Painted Button-quail *Turnix varia*	6	
*Rock Dove *Columba livia*		1
Common Bronzewing *Phaps chalcoptera*	7	1
Crested Pigeon *Ocyphaps lophotes*	6	4
Diamond Dove *Geopelia cuneata*	1	
Peaceful Dove *Geopelia striata*	9	1
Bar-shouldered Dove *Geopelia humeralis*	3	
Wonga Pigeon *Leucosarcia melanoleuca*	2	1
Glossy Black-Cockatoo *Calyptorhynchus lathami* V	2	
Yellow-tailed Black-Cockatoo *Calyptorhynchus funereus*	1	
Galah *Cacatua roseicapilla*	9	5
Little Corella *Cacatua sanguinea*		1
Sulphur-crested Cockatoo *Cacatua galerita*	7	4
Cockatiel *Nymphicus hollandicus*	6	4
Rainbow Lorikeet *Trichoglossus haematodus*	5	4
Scaly-breasted Lorikeet *Trichoglossus chlorolepidotus*	1	1
Musk Lorikeet *Glossopsitta concinna*	5	1
Little Lorikeet *Glossopsitta pusilla*	8	2
Australian King-Parrot *Alisterus scapularis*	4	1
Red-winged Parrot *Aprosmictus erythropterus*	6	4
Crimson Rosella *Platycercus elegans*	6	1
Eastern Rosella *Platycercus eximius*	8	3
Pale-headed Rosella *Platycercus adscitus*	5	3
Australian Ringneck *Barnardius zonarius*	1	
Red-rumped Parrot *Psephotus haematonotus*	6	4
Turquoise Parrot *Neophema pulchella* V	7	2
Pallid Cuckoo *Cuculus pallidus*	9	2
Brush Cuckoo *Cacomantis variolosus*	3	
Fan-tailed Cuckoo *Cacomantis flabelliformis*	6	2
Black-eared Cuckoo *Chrysococcyx osculans*	2	
Horsfield's Bronze-Cuckoo *Chrysococcyx basalis*	4	1
Shining Bronze-Cuckoo *Chrysococcyx lucidus*	4	1
Little Bronze-Cuckoo *Chrysococcyx minutillus*	1	
Common Koel *Eudynamys scolopacea*	2	2
Channel-billed Cuckoo *Scythrops novaehollandiae*	5	1
Powerful Owl *Ninox strenua* V	1	
Southern Boobook *Ninox novaeseelandiae*	7	2
Tawny Frogmouth *Podargus strigoides*	7	3
White-throated Nightjar *Eurostopodus mystacalis*	3	
Australian Owlet-nightjar *Aegotheles cristatus*	8	
White-throated Needletail *Hirundapus caudacutus*	4	
Azure Kingfisher *Alcedo azurea*	2	2
Laughing Kookaburra *Dacelo novaeguineae*	9	3
Red-backed Kingfisher *Todiramphus pyrrhopygius*	1	
Sacred Kingfisher *Todiramphus sanctus*	8	3
Rainbow Bee-eater *Merops ornatus*	6	2
Dollarbird *Eurystomus orientalis*	7	4
Superb Lyrebird *Menura novaehollandiae*	1	
White-throated Treecreeper *Cormobates leucophaeus*	10	4
Brown Treecreeper *Climacteris picumnus* V	10	4
Superb Fairy-wren *Malurus cyaneus*	10	5
Variegated Fairy-wren *Malurus lamberti*	6	2
Spotted Pardalote *Pardalotus punctatus*	9	2
Striated Pardalote *Pardalotus striatus*	9	4
White-browed Scrubwren *Sericornis frontalis*	6	3
Chestnut-rumped Heathwren *Hylacola pyrrhopygia*	1	

Species	>300 ha (10)	<100 ha (5)
Speckled Warbler *Chthonicola sagittata* V	8	4
Weebill *Smicrornis brevirostris*	10	3
Western Gerygone *Gerygone fusca*	3	
White-throated Gerygone *Gerygone olivacea*	9	3
Brown Thornbill *Acanthiza pusilla*	4	
Inland Thornbill *Acanthiza apicalis*	4	2
Buff-rumped Thornbill *Acanthiza reguloides*	7	2
Yellow-rumped Thornbill *Acanthiza chrysorrhoa*	8	3
Yellow Thornbill *Acanthiza nana*	10	2
Striated Thornbill *Acanthiza lineata*	6	2
Southern Whiteface *Aphelocephala leucopsis*	2	
Red Wattlebird *Anthochaera carunculata*	7	1
Spiny-cheeked Honeyeater *Acanthagenys rufogularis*	9	2
Striped Honeyeater *Plectorhyncha lanceolata*	9	2
Noisy Friarbird *Philemon corniculatus*	10	5
Little Friarbird *Philemon citreogularis*	6	3
Blue-faced Honeyeater *Entomyzon cyanotis*	3	1
Noisy Miner *Manorina melanocephala*	8	3
Yellow-throated Miner *Manorina flavigula*	2	
Yellow-faced Honeyeater *Lichenostomus chrysops*	10	3
White-eared Honeyeater *Lichenostomus leucotis*	9	1
Yellow-tufted Honeyeater *Lichenostomus melanops*	6	
Fuscous Honeyeater *Lichenostomus fuscus*	9	3
White-plumed Honeyeater *Lichenostomus penicillatus*	8	3
Black-chinned Honeyeater *Melithreptus gularis* V	1	
Brown-headed Honeyeater *Melithreptus brevirostris*	8	1
White-naped Honeyeater *Melithreptus lunatus*	7	1
Brown Honeyeater *Lichmera indistincta*	3	1
Painted Honeyeater *Grantiella picta* V	1	
Eastern Spinebill *Acanthorhynchus tenuirostris*	3	1
Scarlet Honeyeater *Myzomela sanguinolenta*	4	
Jacky Winter *Microeca fascinans*	10	1
Scarlet Robin *Petroica multicolor*	3	
Red-capped Robin *Petroica goodenovii*	5	
Hooded Robin *Melanodryas cucullata* V	3	
Eastern Yellow Robin *Eopsaltria australis*	9	4
Grey-crowned Babbler *Pomatostomus temporalis* V	3	
White-browed Babbler *Pomatostomus superciliosus*	5	
Varied Sittella *Daphoenositta chrysoptera*	10	
Crested Shrike-tit *Falcunculus frontatus*	6	1
Golden Whistler *Pachycephala pectoralis*	7	3
Rufous Whistler *Pachycephala rufiventris*	10	3
Grey Shrike-thrush *Colluricincla harmonica*	10	5
Leaden Flycatcher *Myiagra rubecula*	7	1
Restless Flycatcher *Myiagra inquieta*	5	4
Magpie-lark *Grallina cyanoleuca*	8	4
Grey Fantail *Rhipidura fuliginosa*	10	4
Willie Wagtail *Rhipidura leucophrys*	10	5
Black-faced Cuckoo-shrike *Coracina novaehollandiae*	10	3
White-bellied Cuckoo-shrike *Coracina papuensis*	7	2
Cicadabird *Coracina tenuirostris*	6	
Ground Cuckoo-shrike *Coracina maxima*	1	
White-winged Triller *Lalage sueurii*	6	1
Olive-backed Oriole *Oriolus sagittatus*	8	2
White-browed Woodswallow *Artamus superciliosus*	4	
Dusky Woodswallow *Artamus cyanopterus*	8	1
Little Woodswallow *Artamus minor*	1	
Grey Butcherbird *Cracticus torquatus*	8	
Pied Butcherbird *Cracticus nigrogularis*	7	5
Australian Magpie *Gymnorhina tibicen*	9	5
Pied Currawong *Strepera graculina*	10	4
Australian Raven *Corvus coronoides*	9	2
Torresian Crow *Corvus orru*	7	3
White-winged Chough *Corcorax melanoramphos*	8	2
Apostlebird *Struthidea cinerea*	4	
Zebra Finch *Taeniopygia guttata*	2	
Double-barred Finch *Taeniopygia bichenovii*	9	3
Plum-headed Finch *Neochmia modesta*	1	2
Red-browed Finch *Neochmia temporalis*	6	2
Diamond Firetail *Stagonopleura guttata* V	8	3
Mistletoebird *Dicaeum hirundinaceum*	10	4
White-backed Swallow *Cheramoeca leucosternus*	2	2
Welcome Swallow *Hirundo neoxena*	8	4
Tree Martin *Hirundo nigricans*	5	
Fairy Martin *Hirundo ariel*	1	2
Rufous Songlark *Cincloramphus mathewsi*	7	
Silvereye *Zosterops lateralis*	9	3
*Common Starling *Sturnus vulgaris*	1	2

Coastal and escarpment forest species (Wonga Pigeon, Superb Lyrebird) were recorded on the western side of the Beardy River gorge (to the west of Torrington State Conservation Area; see Fig. 1). The Glossy Black-Cockatoo was recorded around the Severn River gorge and adjoining rugged country, where it fed on Woolly She-oak *Allocasuarina inophloia*. A territorial Powerful Owl was recorded in a tributary gorge of the Severn River. Some species occurred only at the most north-westerly survey sites in 1997 (Emu, Little Corella, Australian Ringneck, Little Bronze-Cuckoo, Red-backed Kingfisher, Ground Cuckoo-shrike, Little Woodswallow). Many other northern or inland species were recorded commonly in the northern half of the transect, at lower elevation. The Chestnut-rumped Heathwren was recorded only on rocky outcrops.

Species recorded only in small patches were found only on the Dumaresq River (Whistling Kite, Rock Dove, Little Corella). Species found mainly or commonly in small patches tended to be common, adaptable species characterised as stable or increasing in the sheep–wheat belts in southern Australia (Barrett *et al.* 1994; Saunders and Ingram 1995). Examples include medium to large ground granivores (Crested Pigeon, cockatoos, parrots), and medium to large ground or above-ground carnivores and omnivores (kookaburra, large artamids), that are tolerant of or frequently use open areas. However, the Dollarbird and several passerines, including some from declining guilds (e.g. Yellow Robin, Restless Flycatcher), were also recorded in most small remnants (Table 3).

The Azure Kingfisher was recorded on the slopes at two sites in large patches (Severn River and a permanent tributary of the Beardy River), and in two small patches (both on the Dumaresq River), out of five and three bird survey points, respectively, that were in streamside areas.

Discussion

The greater species total for large patches is explained at least partly by the greater survey effort in those patches; with equal survey time, small patches may have had a similar total (Mac Nally and Horrocks 2002). Conversely, values at the low end of the range recorded for large patches (46 and 62 species per patch) may relate to observer differences: those sites were surveyed by a non-local team using mainly visual rather than aural and visual cues. Habitat attributes providing resources for woodland birds (e.g. tree cover, shrub cover, tall grass, hollows, logs) tended to be more available in large than in small patches (Table 2), a general trend in grazed and fragmented landscapes (Hobbs 2001; Clarke 2003; James 2003). Within-patch habitat variability, which was greater in large patches, could also partly explain the higher totals in large versus small patches, and variation in patch location and habitat could have influenced the results.

The total number of bird species for small patches was almost as great as for large patches, a result partly explained by the fact that four of the five were on rich sites (one on basalt soil, three on riverine alluvium). Furthermore, all small patches were >20 ha and two (including the ridge-top one on poor soil) were >90 ha. Small patches on the sparsely settled slopes scored fairly well in the attributes that provide resources for birds (Table 2), on average better than for small remnants on the tablelands (cf. Appendix 3 of Debus *et al.* 2006). These results are consistent with the finding that small, high-quality patches can support high bird diversity (Fischer and Lindenmayer 2002).

The diversity of bird species recorded in this study was similar to that for Kwiambal National Park, a large reserve (1301 ha) in rugged granitic country 30 km west of the Bonshaw–Texas transect (Fig. 1). Bird counts and nocturnal surveys over three days in December 1997 found 96 species of woodland birds: almost entirely a subset of those in Table 3, and a greater total than the mean for large patches (Table 4). Additional species at Kwiambal were Red-chested Button-quail *Turnix pyrrhothorax* and Barn Owl *Tyto alba*; Turquoise Parrot, Brown Treecreeper and Speckled Warbler were the only threatened species recorded (Appendix 1).

Table 4. Number of bird species recorded by woodland patch size. L = large patch (>300 ha) on private land; S = small remnant (<100 ha) on private land; n = number of patches sampled in each category. Range and mean refer to the number of species per patch in each category; sd = standard deviation.

Category	n	Total species	Range	Mean	sd
L	10	117	46–113	72*	19.5
S	5	106	41–66	52*	10.5

*significantly different (P<0.01)

Extended opportunistic observations in Kings Plains National Park, a large reserve (6919 ha) in rugged granitic country 2 km west of the transect at 880 m elevation, produced 83 native woodland species (Appendix 1): a subset of those in Table 3, with Square-tailed Kite, Glossy Black-Cockatoo, Turquoise Parrot, Brown Treecreeper and Diamond Firetail the only threatened species. This total is similar to the four nearest large patches on private land 5–10 km away (81–88 species), and slightly greater than a small but rich patch on private land 2 km away on the tablelands (70 species: Debus *et al.* 2006). These results suggest that species richness is greater in large patches on private land than in infertile reserves: a function probably of topography and site productivity.

The total of 120 species (Table 3) exceeded that of 109 species (from count-only data) on the tablelands >900 m, for comparable survey effort (Debus *et al.* 2006). The greater species richness on the slopes, compared with the tablelands, is partly explained by the milder climate, and hence probably greater food supply and foraging opportunities, at lower elevation, and by the generally greater vegetation cover on the slopes than on the tablelands (NPWS 2003). The difference is also explained by the location of the study area in the overlap zone between the Eyrean, Torresian and Bassian faunal regions, resulting in a large number of northern and inland birds occurring there. It is apparent that a Torresian avifaunal element penetrates southwards down the inland slopes of northern NSW.

The total of 120 species almost equalled that of 143 species recorded farther south on the North-west Slopes by Oliver *et al.* (1999), whose work entailed greater survey effort over a longer period. Species not recorded by Oliver *et al.*, though found in the present study, are Torresian species that just penetrate the northerly parts of the North-west Slopes (e.g. Pale-headed Rosella, Little Bronze-Cuckoo), or are inland species that do not reach the longitude of Oliver's study (e.g. Emu, Australian Ringneck, Ground Cuckoo-shrike). Both studies on the inland slopes, and that on the tablelands (Debus *et al.* 2006), recorded a similar array of threatened species. Only the present study recorded the Powerful Owl, apparently near its inland limit for that latitude. Others found on the slopes but not recorded on the tablelands were Black-chinned Honeyeater and Grey-crowned Babbler. Conversely, the present study failed to detect the Swift Parrot *Lathamus discolor* and Regent Honeyeater *Xanthomyza phrygia*, and the Barking Owl was not confirmed by a survey record; these species are likely to occur in the study area. All of the species recorded in this study were a subset of the avifauna documented by Ford and McFarland (1991) for the New England region, and Barrett *et al.* (2003) for the relevant one-degree grids. The Little Bronze-Cuckoo, in the large patch just south of Texas (Fig. 1), is a western record for this latitude.

The results of this study suggest that habitat remnants on the upper North-west Slopes <900 m elevation have conservation values similar to those remnants farther south, studied by Oliver *et al.* (1999), and that similar conclusions apply on the importance of larger/richer patches, particularly for threatened and other declining species. The declining or potentially at-risk species seem to be faring better in small patches on the slopes than on the tablelands, for reasons that are as yet unclear. Perhaps climatic extremes at high elevation depress thresholds of tolerance to habitat fragmentation and degradation, or these processes are worse on the heavily cleared tablelands where there are fewer subpopulations and fewer connections between patches. Aspects of resource availability for birds may be pertinent, as patch-scale attributes such as quality and complexity are proving to be at least as important as patch size and landscape context in predicting the occurrence of species (Major *et al.* 2001; Watson 2003; Watson *et al.* 2003). Small, high-quality patches can be valuable for birds (Fischer and Lindenmayer 2002); patch quality is critical over the long term (Watson 2003).

The Azure Kingfisher was again seldom recorded, even in riparian sites, as on the tablelands (Debus *et al.* 2006). The few records in the present study were from she-oak gallery forest or River Red Gum on permanent creeks and rivers. Riparian zones are rich and important habitats, which have suffered degradation on the tablelands and slopes from clearing and grazing, and they require conservation and restoration (Oliver *et al.* 1999; Jansen and Robertson 2001). Revegetation of riparian zones and protection from livestock have been identified as a major priority, not only for biodiversity but also for water quality.

Failure to detect the Squatter Pigeon or Black-throated Finch, in perhaps the last part of NSW where they might be expected, is consistent with the apparent extinction of the finch in NSW (Ley and Cook 2001), and the retreat of these species northwards in Queensland (Garnett and Crowley 2000). These declines are part of a general trend among the ground-feeding granivorous bird guild in tropical and subtropical rangelands (Franklin 1999). This conservation arena is likely to be as important as temperate woodlands for birds.

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APPENDIX I

Appendix 1. Land-bird species recorded at Kwiambal National Park (Kw; 3 days of intensive diurnal and nocturnal surveys by SD, Dec. 1997) and Kings Plains National Park (KP; opportunistic surveys on part-days by SD in Sept. 1986 and April 1995, J. Harris and J. & B. Makepeace in Feb. and Sept.–Nov. 1995–2006, C. Higgins in 1998 and HAF in Sept. 2002). X = present, bold = threatened, underlined = at risk or declining (conventions as in Table 3).

Species	Kw	KP
Square-tailed Kite ***Lophoictinia isura*** V		X
Brown Goshawk *Accipiter fasciatus*	X	X
Wedge-tailed Eagle *Aquila audax*		X
Little Eagle *Hieraaetus morphnoides*	X	X
Peregrine Falcon *Falco peregrinus*		X
Nankeen Kestrel *Falco cenchroides*	X	X
Red-chested Button-quail *Turnix pyrrhothorax*	X	
Painted Button-quail *Turnix varia*	X	
Common Bronzewing *Phaps chalcoptera*	X	X
Crested Pigeon *Ocyphaps lophotes*	X	X
Peaceful Dove *Geopelia striata*	X	X
Bar-shouldered Dove *Geopelia humeralis*	X	
Glossy Black-Cockatoo ***Calyptorhynchus lathami*** V		X
Yellow-tailed Black-Cockatoo *Calyptorhynchus funereus*		X
Galah *Cacatua roseicapilla*	X	X
Sulphur-crested Cockatoo *Cacatua galerita*	X	X
Rainbow Lorikeet *Trichoglossus haematodus*	X	X
Musk Lorikeet *Glossopsitta concinna*		X
Little Lorikeet *Glossopsitta pusilla*	X	X
Australian King-Parrot *Alisterus scapularis*	X	X
Crimson Rosella *Platycercus elegans*		X
Eastern Rosella *Platycercus eximius*	X	X
Pale-headed Rosella *Platycercus adscitus*	X	
Turquoise Parrot ***Neophema pulchella*** V	X	X

Species	Kw	KP
Pallid Cuckoo *Cuculus pallidus*	X	X
Brush Cuckoo *Cacomantis variolosus*	X	
Fan-tailed Cuckoo *Cacomantis flabelliformis*	X	X
Horsfield's Bronze-Cuckoo *Chrysococcyx basalis*	X	
Shining Bronze-Cuckoo *Chrysococcyx lucidus*	X	
Common Koel *Eudynamys scolopacea*	X	
Channel-billed Cuckoo *Scythrops novaehollandiae*	X	
Southern Boobook *Ninox novaeseelandiae*	X	X
Barn Owl *Tyto alba*	X	
Tawny Frogmouth *Podargus strigoides*	X	X
White-throated Nightjar *Eurostopodus mystacalis*	X	
Australian Owlet-nightjar *Aegotheles cristatus*	X	
White-throated Needletail *Hirundapus caudacutus*	X	
Laughing Kookaburra *Dacelo novaeguineae*	X	X
Sacred Kingfisher *Todiramphus sanctus*	X	X
Rainbow Bee-eater *Merops ornatus*	X	X
Dollarbird *Eurystomus orientalis*	X	X
White-throated Treecreeper *Cormobates leucophaeus*	X	X
Brown Treecreeper ***Climacteris picumnus*** V	X	X
Superb Fairy-wren *Malurus cyaneus*	X	X
Variegated Fairy-wren *Malurus lamberti*	X	
Spotted Pardalote *Pardalotus punctatus*	X	X
Striated Pardalote *Pardalotus striatus*	X	X
White-browed Scrubwren *Sericornis frontalis*	X	X
Chestnut-rumped Heathwren *Hylacola pyrrhopygia*		X
Speckled Warbler ***Chthonicola sagittata*** V	X	
Weebill *Smicrornis brevirostris*	X	X
Western Gerygone *Gerygone fusca*	X	
White-throated Gerygone *Gerygone olivacea*	X	X
Inland Thornbill *Acanthiza apicalis*	X	
Buff-rumped Thornbill *Acanthiza reguloides*	X	X
Yellow-rumped Thornbill *Acanthiza chrysorrhoa*	X	X
Yellow Thornbill *Acanthiza nana*	X	X
Red Wattlebird *Anthochaera carunculata*		X
Striped Honeyeater *Plectorhyncha lanceolata*	X	X
Noisy Friarbird *Philemon corniculatus*	X	X
Little Friarbird *Philemon citreogularis*	X	
Blue-faced Honeyeater *Entomyzon cyanotis*	X	
Noisy Miner *Manorina melanocephala*	X	X
Yellow-faced Honeyeater *Lichenostomus chrysops*	X	X
White-eared Honeyeater *Lichenostomus leucotis*	X	X
Yellow-tufted Honeyeater *Lichenostomus melanops*		X
Fuscous Honeyeater *Lichenostomus fuscus*	X	X
White-plumed Honeyeater *Lichenostomus penicillatus*	X	X
Brown-headed Honeyeater *Melithreptus brevirostris*	X	
White-naped Honeyeater *Melithreptus lunatus*	X	X
Brown Honeyeater *Lichmera indistincta*	X	
Eastern Spinebill *Acanthorhynchus tenuirostris*		X

APPENDIX I

Species	Kw	KP
Jacky Winter *Microeca fascinans*	X	X
Scarlet Robin *Petroica multicolor*		X
Red-capped Robin *Petroica goodenovii*	X	
Eastern Yellow Robin *Eopsaltria australis*	X	X
Grey-crowned Babbler ***Pomatostomus temporalis*** V	X	
White-browed Babbler *Pomatostomus superciliosus*		X
Varied Sittella *Daphoenositta chrysoptera*	X	
Crested Shrike-tit *Falcunculus frontatus*	X	
Crested Bellbird *Oreoica gutturalis*		X
Golden Whistler *Pachycephala pectoralis*	X	X
Rufous Whistler *Pachycephala rufiventris*	X	X
Grey Shrike-thrush *Colluricincla harmonica*	X	X
Leaden Flycatcher *Myiagra rubecula*	X	X
Restless Flycatcher *Myiagra inquieta*	X	X
Magpie-lark *Grallina cyanoleuca*	X	X
Grey Fantail *Rhipidura fuliginosa*	X	X
Willie Wagtail *Rhipidura leucophrys*	X	X
Black-faced Cuckoo-shrike *Coracina novaehollandiae*	X	X
White-bellied Cuckoo-shrike *Coracina papuensis*	X	
Cicadabird *Coracina tenuirostris*	X	X
White-winged Triller *Lalage sueurii*	X	X
Olive-backed Oriole *Oriolus sagittatus*	X	X
Dusky Woodswallow *Artamus cyanopterus*	X	X
Grey Butcherbird *Cracticus torquatus*	X	X
Pied Butcherbird *Cracticus nigrogularis*	X	X
Australian Magpie *Gymnorhina tibicen*	X	X
Pied Currawong *Strepera graculina*	X	X
Australian Raven *Corvus coronoides*	X	X
Torresian Crow *Corvus orru*	X	
White-winged Chough *Corcorax melanoramphos*	X	X
Double-barred Finch *Taeniopygia bichenovii*	X	X
Red-browed Finch *Neochmia temporalis*	X	X
Diamond Firetail ***Stagonopleura guttata*** V		X
Mistletoebird *Dicaeum hirundinaceum*	X	X
Welcome Swallow *Hirundo neoxena*	X	X
Tree Martin *Hirundo nigricans*	X	X
Fairy Martin *Hirundo ariel*	X	
Rufous Songlark *Cincloramphus mathewsi*	X	X
Silvereye *Zosterops lateralis*	X	X
*Common Starling *Sturnus vulgaris*		X
Total species	96	84

*significantly different from each other (P<0.01)